



HMT-West 2011 Field Operations Summary

Background

The HMT-West 2011 field season was conducted from 1 December 2010 – 8 March 2011 with a break from 22-27 December (94 total days of operations). The field season consisted of 7 Intensive Operations Periods (IOPs) during which NOAA personnel launched upper air soundings and operated the NOAA SkyWater C-band radar from the Lincoln, California site. The IOPs are described in more detail below.

The 2011 field season represented a unique deployment, due to significant contributions to the existing HMT-West infrastructure from the California Energy Commission (CEC <http://www.energy.ca.gov/>) and the California Department of Water Resources (CADWR <http://www.water.ca.gov/>). The CEC is building on the existing HMT-West instrumentation network through CalWater (<http://www.esrl.noaa.gov/psd/calwater/>), a program complementary to HMT-West that aims to examine the role of aerosols in precipitation as well as to quantify the temporal and spatial variability of atmospheric rivers (ARs) and their representation in climate models. These objectives involve specialized monitoring of the Sierra Barrier Jet (SBJ), which profoundly affects transports of both water vapor and aerosols, and ultimately redistributes orographic precipitation and modifies AR conditions (each of importance to HMT). CalWater (through joint sponsorship from CEC and NOAA Earth System Research Laboratory Physical Sciences Division) contributed to the deployment a number of assets that were used in the 2011 field season, including:

- SkyWater C-band radar at Lincoln;
- Supplemental upper air soundings at Lincoln;
- S-band precipitation profilers (S-profs) at Sugar Pine and Mariposa;
- Atmospheric River Observatory (ARO)/wind profiler at Concord;
- GPS-met observations at Fort Bragg and Shasta; and
- ARO displays, including model inputs, added to several HMT-West profiler sites

In addition, CADWR is contributing to the legacy of HMT-West through enhancements to existing HMT-West instrumentation as well as through deployment of new instrumentation sites in California. CA DWR contributions include:

- four snow level radars (i.e., Shasta Dam, Colfax, Pine Flat Reservoir, New Exchequer Dam);
- 15 new GPS-met sites already installed in northern California and 8 additional sites to be deployed during the 2011 field season; and
- 8 existing and pending soil moisture sites in northern and central California.

Although the CEC CalWater contributions listed above extend over the entire 1 December – 15 March period, the 2011 season included an approximate 5-week period (1 February – 7 March) with an added emphasis on CalWater aerosol (AP) activities. The period of operations from 1 December – 31 January and 7-8 March is referred to as the “**AR Period**” to indicate preferential



sampling of ARs and the Sierra Barrier Jet and resulting effects on precipitation. The period of joint operations from 1 February – 6 March is referred to as the “**AR-AP Period**” to reflect the combined emphasis of HMT-West and CalWater on ARs and CalWater on AP.

Specific assets for the AR and AR-AP periods included:

AR Period: 1 Dec 2010 – 31 January 2011

- SkyWater radar operations
- Lincoln, Oakland and Reno soundings
- Unattended mesonet, including 7 AROs in northern and Central California, 3 S-Prof radar precipitation profilers
- New permanent mesonet sites installed under the DWR-sponsored EFREP/HMT-West Legacy Project, including 2-4 snow-level radars, several GPS-met sites and soil moisture sites

AR-AP Period: 1 Feb – 6 Mar 2011

- Same as AR Period, plus
- ATOFMS ground site at Sugar Pine Dam
- G-1 research aircraft, with
 - ATOFMS aerosol sampler
 - Continuous flow diffusion chamber for measuring ice nuclei
 - Cloud microphysics sensors
 - Aerosol size distribution sensors
 - Water collection for isotope studies
 - Gas phase analyzers
 - Atmospheric thermodynamic sensors

2011 Field Season Highlights

Overall there were 7 AR/SBJ-focused IOPs, with 295 hours of SkyWater radar operations, and 88 special radiosondes launched (71 by PSD from Lincoln, plus 17 supplemental soundings by NWS from Oakland or Reno – see Table 1). During the AR-AP Period there were 28 flights of the PNNL G-1 aircraft, using 71 flight hours. The ATOFMS equipment, gas phase, and other meteorological instruments were operated at Sugar Pine Dam from Feb 1 to March 7. Precipitation samples were collected for the major storms at 4 sites. A wide network of unattended field equipment was in place from 1 December 2010 to 7 March 2011 (Figs. 1 and 2), and was made available in real-time via the web. In addition, specialized HMT numerical model simulations were conducted in real time, daily forecasts and field team deployment decisions were made throughout the period.



25 March 2011

Table 1. Summary of sonde launches and Atmospheric River-Sierra Barrier Jet intensity during the 7 IOPs sampled during HMT-West 2011.

IOP	Number of Lincoln Sondes Launched	Number of NWS Combined Oakland/Reno Sondes Launched	AR present	AR strength (SSM/I)	SBJ present (SHS.CCO)	SBJ strength (m/s) (SHS ARO)
1	7	0	Y	Mid	Y	10-15
2	17	8	Y	Strong	Y (2 SBJs)	25
3	15	9	Y	Mid	Y (2 SBJs)	25
4	9	0	N	None	Y	30
5	4	0	Y	Weak	Y	25-30
6	12	0	Y	Mid	Y	30
7	7	0	Y	Weak	N	10

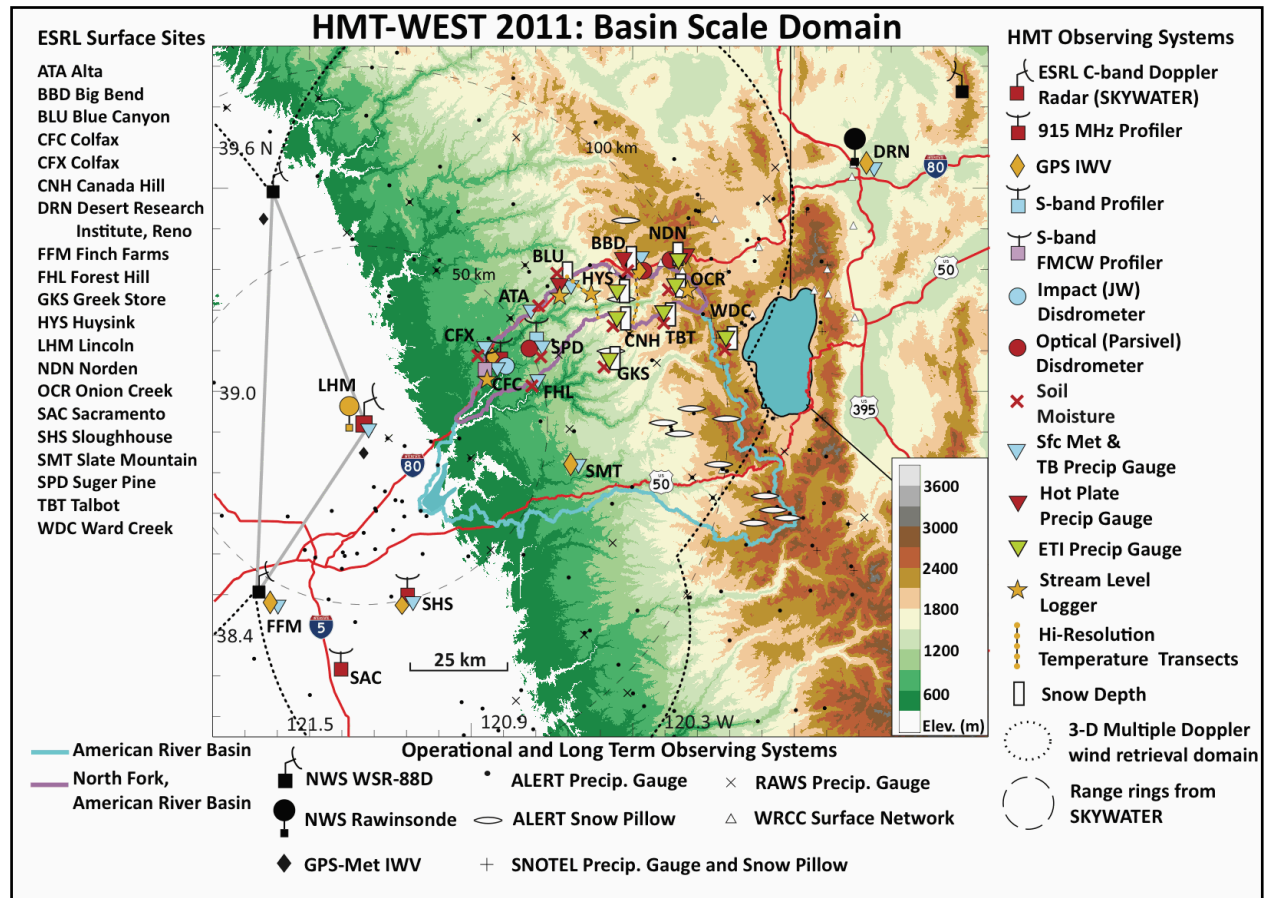


Figure 1. HMT-West 2011 instrument locations in the American River Basin.

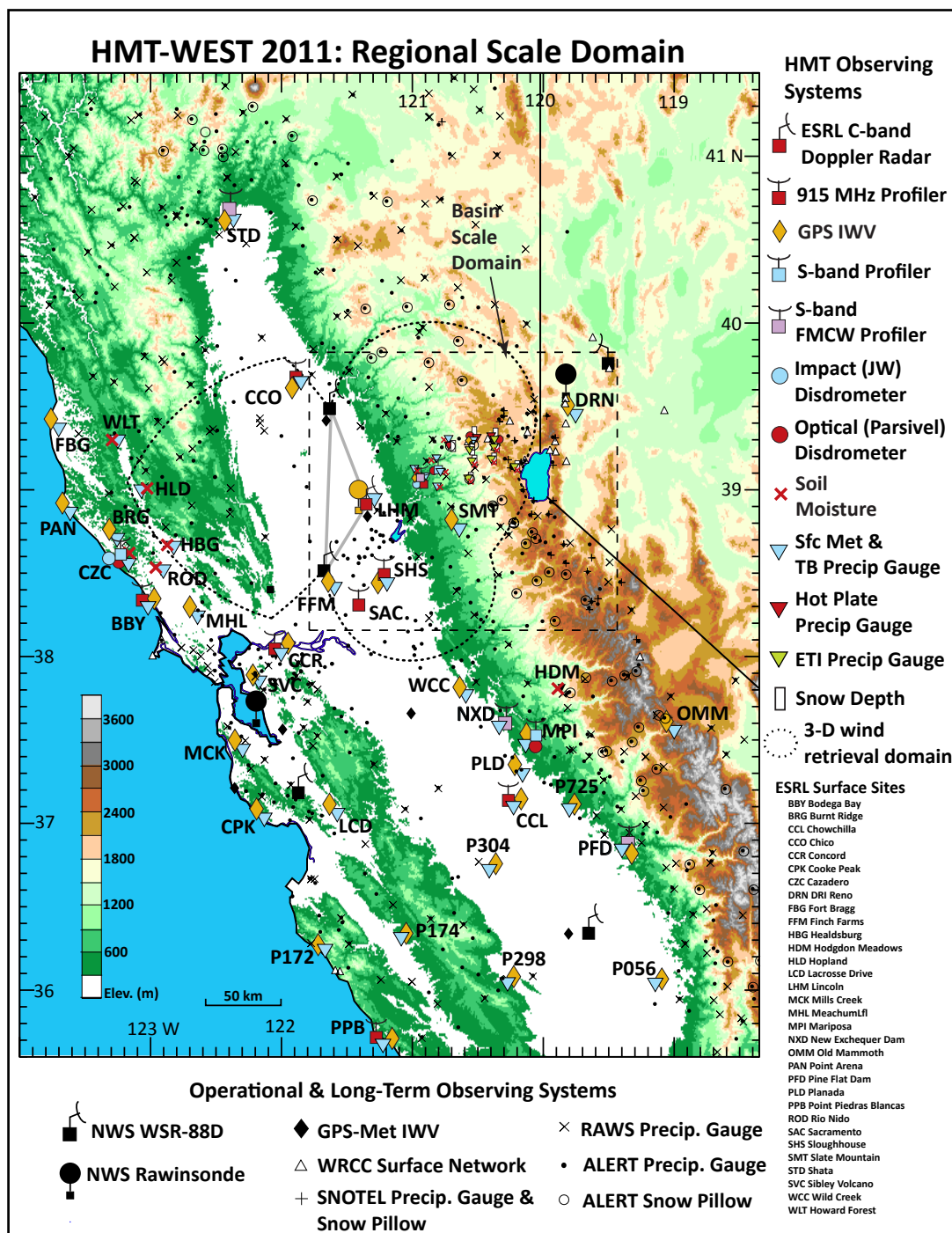


Figure 2. Regional-scale map of HMT-West 2011 instrument locations.

Overall the season produced the major meteorological and aerosol conditions that were required for CalWater and HMT-West to pursue their science objectives, including well above

normal precipitation in the northern Sierra in December and late February (Fig. 3). December 2010 was characterized by a series of intense ARs and heavy rain that affected California, although Central and Southern California bore the brunt of these storms. Some locations in the southern Sierra had received the equivalent of an entire season's snowpack, while the Northern Sierra 8-Station Index recorded 18 inches of accumulation, more than a third of the normal annual total (Fig. 3). An extended AR-focused IOP (IOP 2) was conducted in mid December. In contrast, January and the first half of February were quite dry, and no major IOPs were conducted. The dry period in early February proved useful in troubleshooting the complex system of sensors that had been installed on the G-1 aircraft (Fig. 4).

By the time significant precipitation returned to northern California on 14 February the full contingent of airborne and ground-based systems were operational. Over the next three weeks a series of storms struck the region, starting off unusually cold, and ending with warmer conditions. The cold conditions created heavy snow that made reaching the Sugar Pine Dam site difficult and impeded operations there and at a couple of other field sites. Overall, more than 20 inches of rain (or melted snow) fell at key CalWater/HMT sites in the Sierra on the 19 dates on which IOPs occurred. On these same 19 dates, over 120 inches of daily snow accumulation occurred at Norden in the Sierras, and snow depth reached over 10 feet at multiple experiment sites in the Sierra (Fig. 5).

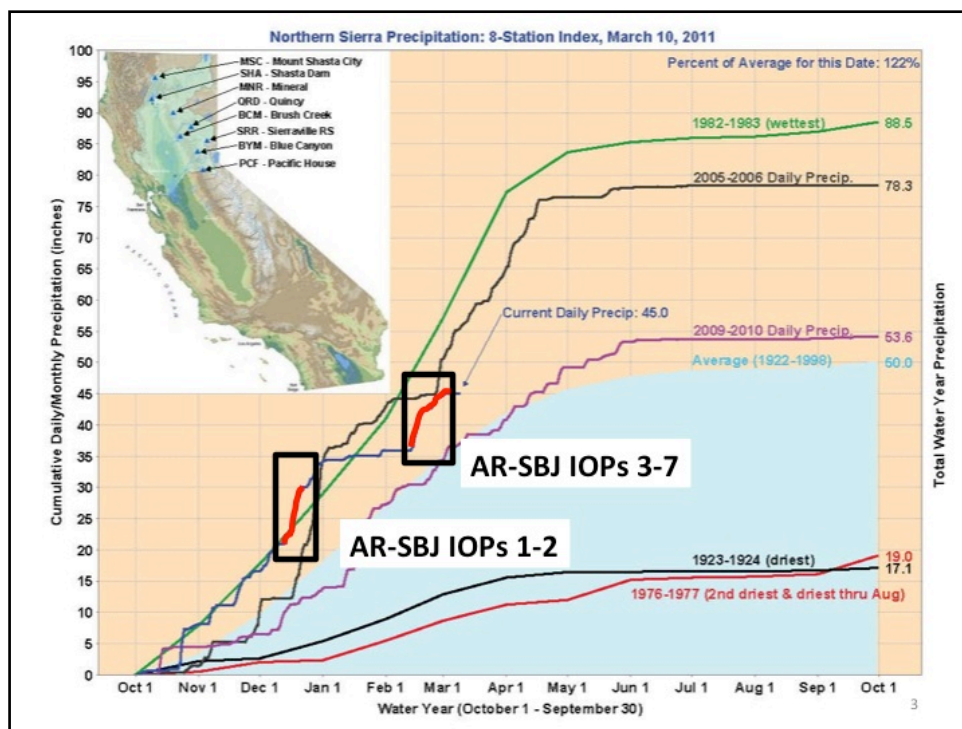


Figure 3. Time series of 2011 water year (blue) compared to selected previous years for 8 station average (locations shown in inset) in northern Sierra. Note that the 2011 time series ends on 10 March 2011.



Figure 4. DOE/PNNL G-1 research aircraft carrying aerosol and microphysics payload during CalWater 2011. Photo with storm approaching McClellan air field near Sacramento, California. Photo by Marty Ralph (NOAA/PSD), 16 February 2011.



Figure 5. 10 feet of snow at HMT/CalWater site at Big Bend, CA. Precipitation gage with wind screen (foreground). Instrument trailer is beneath snow pile in background. Photo by Clark King (NOAA/PSD) about 1 March 2011.

Aerosols from California and from Asia, as well as pristine maritime conditions were observed both in cloud and clear air, from the coastal ocean and mountains to the Central Valley and Sierra. 8 Sierra Barrier Jets (SBJ) were captured along with 6 AR events. A summary of precipitation totals for the IOPs is provided in Table. 2.



25 March 2011

Table 2. Dates and liquid equivalent precipitation accumulation for the 7 IOPs sampled during HMT-West 2011.

IOP	Dates (YYMMDD HH)	Total Hours	ATA (in)	BLU (in)	CFX (in)	CZC (in)	NDN (in)	SPD (in)
1	101215 00Z 101216 00Z	24	0.5	0.7	0.5	0.0	1.1	0.9
2	101217 18Z 101220 04Z	58	5.4	7.5	5.4	3.0	7.9	8.3
3	110214 00Z 110217 00Z	72	2.5	4.0*	1.5	6.8**	3.6	3.7
4	110217 12Z 110219 12Z	48	1.7	2.9*	1.4	0.8	3.3*	2.2
5	110224 18Z 110226 18Z	48	2.6	3.4*	1.6	0.8	3.6	NA
6	110301 06Z 110304 00Z	66	NA	2.2*	0.7	1.8	1.8*	1.2
7	110306 00Z 110307 1730Z	41.5	1.9	2.5*	1.6	0.6	1.6	2.0

NA – missing at least part of time series

* Hot plate gauge (all other accumulations are tipping bucket or ETI)

** No data after 20Z on 19 Feb

Also, two of the events monitored by CalWater/HMT in northern California were also monitored by aircraft well offshore as part of other programs' investigations of atmospheric rivers. On 11-12 February 2011 the first-ever scientific dropsonde mission of the NASA Global Hawk unmanned aircraft was conducted over the eastern Pacific, including two major transects over an AR northeast of Hawaii. This was part of the Winter Storms and Pacific Atmospheric Rivers experiment (WISPAR). Then, on 3-4 March, the second Global Hawk dropsonde mission also sampled an AR over the ocean between Hawaii and California, while the NOAA G-IV aircraft conducted an AR-focused dropsonde leg with an AR "water vapor budget box." The NOAA G-IV was in Hawaii for NOAA/NCEP's Winter Storms Reconnaissance Program and was able to conduct the special AR sampling through coordination with the WISPAR experiment. A third dropsonde flight was conducted by the Global Hawk on 8-9 March, and sampled an AR approaching California.

Operations summaries for each IOP can be found at

http://hmt.noaa.gov/field_programs/hmt-west/2011/ops/